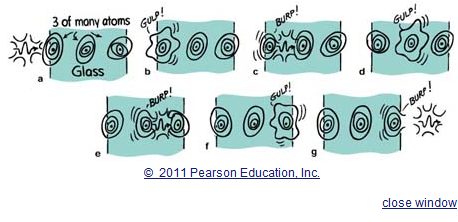
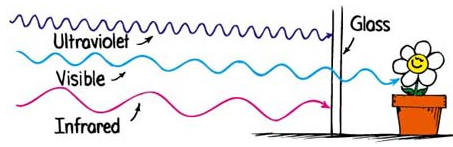
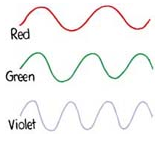
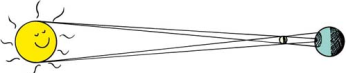
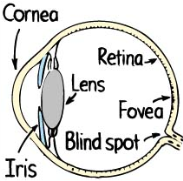
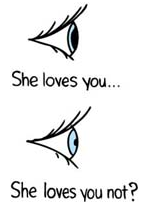
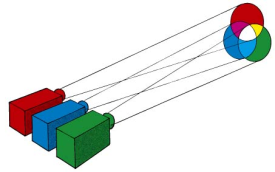
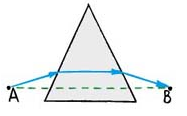
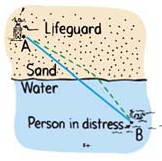
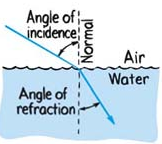
Light part 6 Notes

**Ch. 26: Properties of Light; 27: Color; 28 Reflection & Refraction; 29 Light Waves: 30 Light Emission**

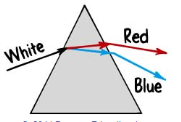
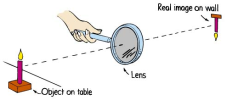
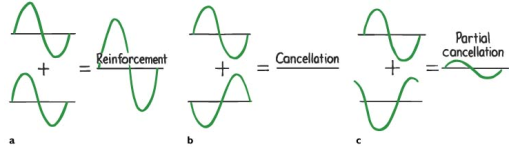
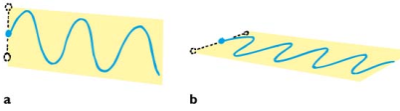
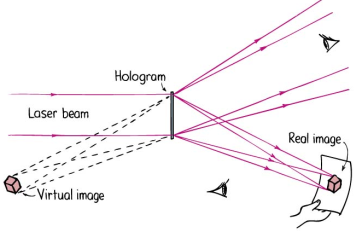
1. Electromagnetic fields- An electric field surround a changing magnetic field. A magnetic field surrounds an electric current. If a magnetic field is oscillating it produces an oscillating electric field (& backwards). The vibrating electric and magnetic fields regenerate each other to make up an [**electromagnetic wave**](javascript:;), which emanates (moves outward) from the vibrating charge. *The electric and magnetic fields of an electromagnetic wave are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ to each other and to the direction of motion of the wave.*
2. James Clerk *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  – “We can scarcely avoid the conclusion that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena. His work in electromagnetism has been called the second great unification in physics.” He calculated the speed of light and found it to be *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* km/sec and realized that EM radiation of any frequency propagates at the same speed as light. That *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  is EM radiation within a frequency of 4.3 × 1014 to 7 × 1014 vibrations/sec
3. **The Electromagnetic Spectrum-** classification of electromagnetic waves according to *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* - differing principally in frequency and wavelength; all travel at the same speed in free space. Because the vibrating electric and magnetic fields regenerate each other to make an electromagnetic wave, there is only one speed that allows the waves to remain in perfect balance. At only one speed does mutual induction continue indefinitely, carrying energy forward without loss or gain. If they speed up, energy would *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*, if they are slower, the waves would *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  out. Law of conservation of energy. There is only one speed, it turns out, for which the electric and magnetic fields remain in perfect balance, reinforcing each other as they carry energy through space.
4. Since the speed of the wave is 300,000 kilometers per second, an electric charge oscillating once per second (1 hertz) will produce a wave with a wavelength of 300,000 kilometers.
5. Gravity can change the frequency of light or deflect light, but it can’t change the speed of light.
6. The universe is a dense sea of radiation in which occasional concentrates are suspended. EM waves surround us (ex. radio & TV signals) but you need a receiver that can pick up and vibrate with the same or close to the same vibrations (would be weaker signal if only close).
7. Materials- The natural frequency of the Material and the frequency of the light determine what is transmitted
8. *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* - rays travel through in straight lines. - can see the image perfectly.
9. *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* absorbs light without reemitting it. Metals are shiny because light that shines on them forces free electrons into vibration and these vibrating electrons then emit their “own” light waves as reflection. Vibrations are turned into random kinetic energy, (become slightly*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*) —into internal energy.
10. *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* allows some light through but the light is scattered and does not have a clear image.
11. Relative wavelengths of red, green, and violet light. Violet light has nearly twice the frequency of red light, and half the wavelength.
12. Free electrons in every piece of metal on the Earth’s surface continually dance to the rhythms of *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*.
13. The natural vibration frequencies of an electron depend on how strongly it is attached to its atom or molecule. Electrons in the atoms of glass have a natural vibration frequency in the ultraviolet range. when ultraviolet waves shine on glass, *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* e occurs and the vibration of electrons builds up.
14. A wave of visible light incident upon a pane of glass sets up in atoms vibrations that produce a chain of *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  and *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*, which pass the light energy through the material and out the other side. Because of the time delay between absorptions and reemissions, the light travels through the glass more slowly than through empty space.
15. The energy any glass atom receives is either reemitted or passed on to neighboring atoms by *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*, there is a slight time delay between absorption and reemission.
16. Resonating atoms in the glass can hold onto the energy of the ultraviolet light for quite a long time, and it collides with neighboring atoms and gives up its energy as heat. Glass is not transparent to ultraviolet light.
17. Glass is transparent to all the frequencies of visible light.
18. **Different materials have different molecular structures and therefore absorb or reflect light from various spectral ranges differently.**
19. **Speed of light c.** The speed of light in a vacuum is a constant 300,000 kilometers per second. In water, light travels at 75% of its speed in a vacuum, or 0.75 c. In glass, light travels at about 0.67 c, depending on the type of glass. In a diamond, light travels at less than half its speed in a vacuum, only 0.41 c. When light emerges from these materials into the air, it travels at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
20. ****Infrared waves, with frequencies lower than those of visible light, vibrate not only the electrons, but entire atoms or molecules which increases the internal energy and \_\_\_\_\_\_\_\_\_\_\_\_\_ of the structure (often called heat waves). Glass blocks both infrared and ultraviolet, but it is transparent to visible light.
21. Earth’s atmosphere is \_\_\_\_\_\_\_\_\_\_\_\_\_ to small amounts of ultraviolet that does get through and is responsible for sunburns. (would be fried to a crisp if it all got through)
22. Things look darker when they are wet because light bounces around inside the transparent wet region before it reaches your eye. Each bounce absorbs light and the surface looks darker.
23. **Shadows-** A thin beam of light is often called a \_\_\_\_\_\_\_\_\_\_\_\_\_.
24. \_\_\_\_\_\_\_\_\_\_\_\_\_—a region where light rays cannot reach.
25. sharp shadow- produce by either a large, far-away light (sun) source or a small, nearby light source
26. \_\_\_\_\_\_\_\_\_\_\_\_\_A total shadow ; penumbra - a partial

1. [**Solar eclipse**](javascript:;). the shadow of the Moon falls on the Earth-
2. Lunar Eclipse- A full Moon is seen when the Earth is between the Sun and the Moon. When this alignment is perfect, the Moon is in Earth’s shadow, and a lunar eclipse is produced

**The Eye-**

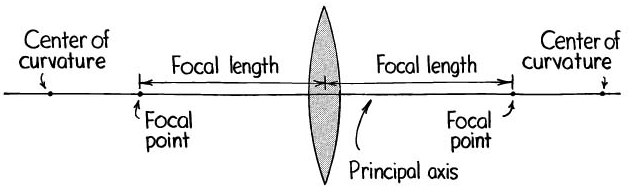
1. **\_\_\_\_\_\_\_\_\_\_\_\_\_,** which does about 70% of the necessary bending of the light before the light passes through the pupil
2. **\_\_\_\_\_\_\_\_\_\_\_\_\_**provides the extra bending power needed to focus images
3. **\_\_\_\_\_\_\_\_\_\_\_\_\_**—back of eye where. The retina is not uniform
4. **\_\_\_\_\_\_\_\_\_\_\_\_\_**a spot in the retina where nerves carrying all the information exit along optic nerve
5. **\_\_\_\_\_\_\_\_\_\_\_\_\_**spot in the center of our field of view - the region of most distinct vision.
6. ****Two basic kinds of Antennae on retina- pick up light. Rods- black/white vision- stimulated by low-frequency light, predominate toward the periphery of the retina. Cones-responsible for color vision and are very dense in the fovea. There are three types of cones which are activated by differing frequencies of light. On the periphery of your vision, you can see an object and its color only if it is moving. Stars that look white are actually brightly colored. A time exposure reveals reds and red-oranges for the “cooler” stars and blues and blue-violets for the “hotter” stars.
7. Because a certain amount of information is combined from several visual receptors and “digested” in the retina it provides evidence of what you like or dislike. If we see, smell, taste, or hear something \_\_\_\_\_\_\_\_\_\_\_\_\_ to us, our pupils automatically contract.
8. **27 Color--\_\_\_\_\_\_\_\_\_\_\_\_\_**  showed that sunlight can break up white light into the rainbow colors- ROYGBIV; also found that when a second prism was used to the rainbow, the colors were recombined to produce white light. The colors of things depend on the colors of the light that illuminates them, or the frequency of the light. Low frequencies- red; high frequencies- ­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. Objects only reflect part of the energy/frequencies which hit them while some light is reemitted; some is absorbed and \_\_\_\_\_\_\_\_\_\_\_\_\_ the substance or passed through. The color you see when light hits something is based on that color being present in the light which hits the object and being \_\_\_\_\_\_\_\_\_\_\_\_\_off. You see the color that is being reflected. White light contains all colors, so when an object is in white light, the color red would indicate that red is the color reflected and all other colors are absorbed and the object would heat up slightly. If a red ball is hit with a red light, the ball appears red because the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, but there are no other colors to be absorbed and no energy is absorbed. If a green light hits a red ball, the green is absorbed, but there is no red light to be reflected back and the object appears black. If a Purple (red + blue) light is shown on the ball, the ball will absorb the \_\_\_\_\_\_\_\_\_\_\_\_\_ light and reflect the \_\_\_\_\_\_\_\_\_\_\_\_\_, and will appear a \_\_\_\_\_\_\_\_\_\_\_\_\_color.
10. The intensity of light from the Sun varies with frequency, being most intense in the \_\_\_\_\_\_\_\_\_\_\_\_\_part of the spectrum. It is interesting to note that our eyes have evolved to have maximum sensitivity in this range.
11. All the colors added together produce\_\_\_\_\_\_\_\_\_\_\_\_\_. The absence of all color is \_\_\_\_\_\_\_\_\_\_\_\_\_. Red, green, and blue light can form white light.
12. [**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_colors**](javascript:;). -Where two of the three colors overlap, another color is produced; any two of these colors of light add to produce another color.
13. **\_\_\_\_\_\_\_\_\_\_\_\_\_ Colors-** two of the three additive primary colors are combined: Red + Blue = Magenta; Red + Green = Yellow; Blue + Green = Cyan.
14. We say that magenta is the opposite of green; cyan is the opposite of red; and yellow is the opposite of blue. When we add each of these colors to its opposite, we get \_\_\_\_\_\_\_\_\_\_\_\_\_.
15. Magenta + Green = *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  (= Red + Blue + Green); Yellow + *\_\_\_\_\_\_\_\_\_\_\_\_\_\_* = White (= Red + Green + Blue)  
    *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  + Red = White (= Blue + Green + Red)
16. [*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  **colors**](javascript:;). -When two colors are added together to produce white
17. Mixing pigments in paints and dyes is entirely different from mixing lights. Pigments are tiny particles that *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  specific colors. Pigments that produce the color red absorb the complementary color cyan. In effect, cyan has been subtracted from white light.
18. [*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* **primaries**](javascript:;)**-** colors magenta, cyan, and yellow. Yellow, cyan, and magenta dyes will produce nearly any color in the spectrum. Something painted blue absorbs yellow, and so reflects all the colors except yellow. Take yellow away from white and you’ve got blue.
19. **Why the Sky Is Blue-** the blue of the sky,is the result of *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*. The tinier the particle, the greater the amount of higher-frequency light it will reemit. The nitrogen and oxygen molecules that make up most of the atmosphere are like tiny bells that “ring” with high frequencies when energized by sunlight. The reemitted light is scattered. *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  is scattered the most by nitrogen and oxygen in the atmosphere, followed by blue, green, yellow, orange, and red, in that order. The blue of the sky varies based on several factors. The principal factor is the *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* content of the atmosphere. On clear, dry days, the sky is a *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  blue than on clear days with high humidity. Pollution and other particles larger than oxygen and nitrogen molecules have lower frequencies and it takes on a whitish appearance. After a heavy rainstorm when the particles have been washed away, the sky becomes a deeper blue. In clean air, the scattering of high-frequency light provides a blue sky. When the air is full of particles larger than molecules, lower-frequency light is also scattered, which adds to the blue to give a *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* sky.
20. **Why Sunsets Are Red-** a sunbeam must travel through*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* of the atmosphere at sunset than at noon. As a result, more blue is scattered from the beam at sunset than at noon. By the time a beam of initially white light reaches the ground, only light of the lower frequencies survives to produce a red sunset.
21. Why Clouds Are White- A cloud is composed of water droplets of various sizes. The tiniest droplets scatter *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  light, slightly larger ones scatter green light, and still larger ones scatter red light. The result is a white cloud.
22. **Why Water Is Greenish Blue-** Water is cyan because it absorbs *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* light. The froth in the waves is white because, like clouds, it is composed of a variety of tiny water droplets that scatter light of all the visible frequencies.
23. **Reflection- is bouncing off. Light interacts with atoms as sound interacts with tuning forks** **causing** *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***.**
24. [**Fermat’s principle of***\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  **time**](javascript:;). Fermat’s idea was this: Out of all possible paths that light might travel to get from one point to another; it travels the path that requires the *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  time.**;** light will take the most *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  path and travel in a straight line if there is nothing to obstruct the passage of light between the 2 points A lifeguard at a beach spots a person in distress in the water. You can run faster than you can swim. Should you travel in a straight line to get to B? The path of shortest time is shown by the dashed-line path, which clearly is not the path of the shortest distance. The amount of bending at the shoreline depends on how much faster you can run than swim.
25. **Law of Reflection-** different points on the mirror vary as to how long it takes the light to \_\_\_\_\_\_\_\_\_\_\_\_\_
26. [**law of reflection**](javascript:;), and it holds for all angles - **The angle of incidence equals the angle of reflection.**
27. It is customary to measure angles of incident and reflected rays from the reflecting surface- from a line perpendicular to plane of reflecting surface. This imaginary line is called the \_\_\_\_\_\_\_\_\_\_\_\_\_The incident ray, the normal, and the reflected ray all lie in the same plane.
28. **Diffuse Reflection-** light is incident on a\_\_\_\_\_\_\_\_\_\_\_\_\_surface and is reflected in \_\_\_\_\_\_\_\_\_\_\_\_\_ directions. If the surface is so smooth there is very little diffuse reflection, and the surface is said to be polished. A surface may be polished for radiation of a long wavelength but not polished for light of a short wavelength.
29. **Refraction- process where** light \_\_\_\_\_\_\_\_\_\_\_\_\_ in passing from one medium to another. A ray of light bends and takes a longer path when it encounters glass or water at an oblique angle but the longer path taken is nonetheless the path requiring the least time.

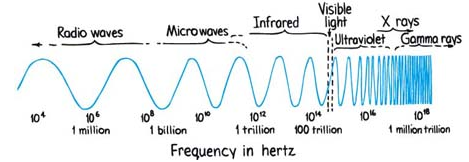
Refraction through glass. Example- **the prism** has opposite faces of the glass that are not parallel. Light that goes through will not follow a straight-line path b/c light will follow the solid line—and pass through a thinner section of the glass the prism. The path followed is the path of \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. A converging lens- The curve decreases thickness of the glass correctly to compensate for the extra distances light travels to points higher on the surface.
2. **\_\_\_\_\_\_\_\_\_\_\_\_\_**Viewing an object over hot pavement, we see a wavy, shimmering effect due to the various least-time paths of light as it passes through varying temperatures and therefore varying densities of air. The twinkling of stars results from similar phenomena in the sky Light from the sky picks up speed in the air near the ground because that air is warmer and less dense than the air above. When the light grazes the surface and bends upward, the observer sees a mirage.
3. Because of refraction, submerged objects appear to be \_\_\_\_\_\_\_\_\_\_\_\_\_.
4. Dispersion by a prism makes the components of white light visible
5. The speed of light in a transparent medium depends on its\_\_\_\_\_\_\_\_\_\_\_\_\_.
6. Because different frequencies of light travel at different speeds in transparent materials, they refract by different amounts.
7. **Rainbows are** illustrations of \_\_\_\_\_\_\_\_\_\_\_\_\_This separation of light into colors arranged according to frequency is called dispersion. All rainbows would be completely rounded if the ground were not in the way. A ray of sunlight enters a drop near its top surface some of the light is reflected & the remainder is refracted into water. **Sunlight incident on two sample raindrops, emerges from them as dispersed light. The observer sees the red light from the upper drop and the violet light from the lower drop. Millions of drops produce the whole spectrum of visible light.**Your cone of vision that intersects the cloud of drops that creates your rainbow is different from that of a person next to you. Everybody sees his or her own personal rainbow.
8. **Total Internal Reflection** - **Light emitted in the water is partly refracted and partly reflected at the surface.****** The light striking the air–water surface obeys the law of reflection: The angle of incidence is equal to the \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_. The only light emerging from the surface of the water is that which is diffusely reflected from the bottom of the bathtub. The critical angle for a diamond is about 24.5°, smaller than for any other known substance.
9. **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_light** is “piped” by a succession of total internal reflections until it emerges at the top ends.
10. Plane Mirrors- **A \_\_\_\_\_\_\_\_\_\_\_\_\_ image is formed behind the mirror and is located at the position where the extended reflected rays (dashed lines) converge.** An observer sees an image of flame at this point but the rays do not actually come from this point, so the image is called a **\_\_\_\_\_\_\_\_\_\_\_\_\_ image**. The image is as far behind the mirror as he is in front and is the same size. It has the same color of clothing—evidence that light doesn’t change frequency upon reflection. The virtual image formed by a convex mirror (a mirror that curves outward) is smaller and closer to the mirror than the object. If object is close to a concave mirror (a mirror that curves inward like a “cave”), the virtual image is larger & farther away than the object. **Although each ray obeys the law of reflection, the many different surface angles that light rays encounter in striking a rough surface cause reflection in many directions.**
11. **Lensees-** [**\_\_\_\_\_\_\_\_\_\_\_\_\_lens**](javascript:;)**-** middle is thinner than the edges, and it diverges the light. The greatest deviation of rays occurs at the outermost prisms, for they have the greatest angle between the two refracting surfaces.
12. A converging lens provides an enlarged, right-side-up image only when the object is inside the focal point. **The image appears larger and farther from the lens than the object.**
13. a [**\_\_\_\_\_\_\_\_\_\_\_\_\_ image**](javascript:;) **When an object is far from a converging lens (beyond its focal point), a real upside-down image is formed.**
14.  When a diverging lens is used alone, the image is always \_\_\_\_\_\_\_\_\_\_\_\_\_,\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_r than the object.
15. **Lens Defects** - No lens provides a perfect image. A distortion in an image is called an \_\_\_\_\_\_\_\_\_\_\_\_\_
16. Aberrations can be minimized using compound lenses, each consisting of several simple lenses, instead of single lenses.
17. Spherical aberration results from light that passes through the \_\_\_\_\_\_\_\_\_\_\_\_\_ of a lens focusing at a slightly different place from where light passing near the center of the lens focuses
18. Chromatic aberration is the result of light of different \_\_\_\_\_\_\_\_\_\_\_\_\_ having different speeds and hence different refractions in the lens b/c different colors of light do not come to focus in the same place.
19. Vision is \_\_\_\_\_\_\_\_\_\_\_\_\_when the pupil is smallest because light then passes through only the central part of the eye’s lens, where spherical and chromatic aberrations are minimal. You see better in bright light because in such light your pupils are smaller.
20. \_\_\_\_\_\_\_\_\_\_\_\_\_ of the eye is a defect that results when the cornea is curved more in one direction than the other
21. Ch. 29
22. **Diffraction**- the bending of light; distortions. **C**onstructive and destructive\_\_\_\_\_\_\_\_\_\_\_\_\_ is not restricted to easily seen water waves but is a property of all waves. Adding, or superposition, - in phase with each other produces a wave of the same frequency but twice the amplitude. If the waves are exactly one-half wavelength out of phase, their superposition results in complete cancellation and **partial cancellation** occurs.
23. **B**oth longitudinal and transverse waves exhibit interference and diffraction effects.
24. **Polarization-** the waves traveling along the rope are confined to a \_\_\_\_\_\_\_\_\_\_\_\_\_  
    Sound waves are \_\_\_\_\_\_\_\_\_\_\_\_\_inal, which means the vibratory motion is along the direction of wave travel. Light waves are transverse. A common light source—such as an incandescent lamp, a fluorescent lamp, a candle flame, or an arc lamp—emits light that is unpolarized. If you look at unpolarized light through a Polaroid filter, you can rotate the filter in any direction, and the light will appear unchanged. But if you are looking at polarized light and you rotate the filter, you can progressively cut off more and more of the light until it is entirely blocked out
25. **Holography-** the light must be of a single frequency and all parts exactly in phase: It must be**\_\_\_\_\_\_\_\_\_\_\_\_\_.** Only a \_\_\_\_\_\_\_\_\_\_\_\_\_ can easily produce such light. Holograpraphy has a two dimensional photographic plate illuminated with laser light that allows you to see a faithful reproduction of a scene in 3D. It is so realistic you can actually look around the sides. No lens is used.

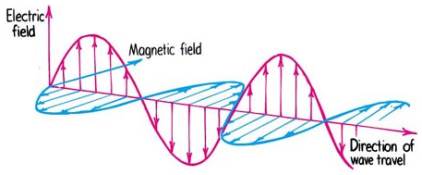
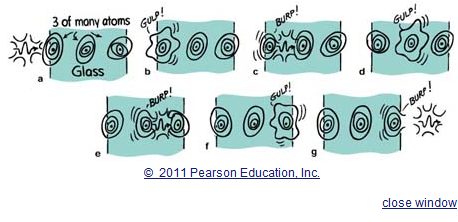
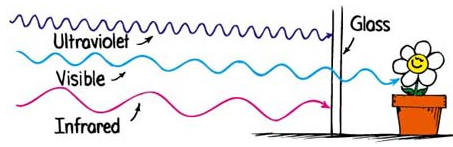
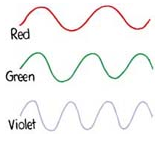
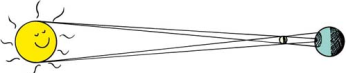
**Ch. 30 Light emission**

1. **\_\_\_\_\_\_\_\_\_\_\_\_\_-** In fluorescence, the energy of the absorbed ultraviolet photon boosts the electron in an atom to a higher energy state. When the electron then returns to an intermediate state, the photon emitted is less energetic and therefore of a lower frequency than the ultraviolet photon.
2. **Fluorescent Lamps-** A fluorescent tube. Ultraviolet (UV) light is emitted by gas in the tube excited by an \_\_\_\_\_\_\_\_\_\_\_\_\_electric current. The UV light, in turn, excites phosphors on the inner surface of the glass tube, which emit white light
3. \_\_\_\_\_\_\_\_\_\_\_\_\_- When excited, certain crystals as well as some large organic molecules remain in a state of excitation for a prolonged period of time and become “stuck.” As a result, there is a \_\_\_\_\_\_\_\_\_\_\_\_\_between the processes of excitation and de-excitation. Used to make glow in the dark objects. A TV screen is slightly phosphorescent, with an afterglow which may last more than an hour. Examples include \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
4. **Lasers-** (light amplification by stimulated emission of radiation). Was predicted by \_\_\_\_\_\_\_\_\_\_\_\_\_in 1917. A beam of incoherent light spreads out after a short distance, becoming wider and less intense with increased distance.   
       A beam of photons having the same frequency, phase, and direction—that is, a beam of photons that are identical copies of one another—is said to be **\_\_\_\_\_\_\_\_\_\_\_\_\_t**. A beam of coherent light spreads and weakens very little.   
       A laser is a device that produces a beam of coherent light. Every laser has a source of atoms called an active medium, which can be a gas, liquid, or solid (the first laser was a ruby crystal). The atoms in the medium are excited to metastable states by an external source of energy. When most of the atoms in the medium are excited, a single photon from an atom that undergoes de-excitation can start a chain reaction. This photon strikes another atom, stimulating it into emission, and so on, and producing coherent light. Most of this light is initially moving in random directions. Light traveling along the laser axis, however, is reflected from mirrors coated to reflect light of the desired wavelength selectively. One mirror is totally reflecting, while the other is partially reflecting. The reflected waves reinforce each other after each round-trip reflection between the mirrors, thereby setting up a to-and-fro \_\_\_\_\_\_\_\_\_\_\_\_\_ condition wherein the light builds up to an appreciable intensity. The light that escapes through the more transparent-mirrored end makes up the laser beam.
5. **A laser beam is not seen unless it \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Like sunbeams or moonbeams, what you see are the particles in the scattering medium, not the beam itself. When the beam hits a diffuse surface, part of it is scattered toward your eye as a dot.**  Lasers have found wide use in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_¸\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_

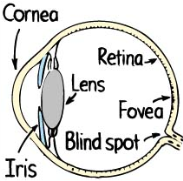
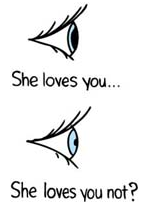
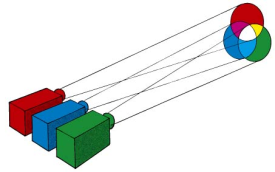
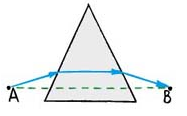
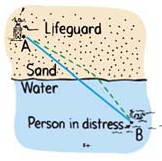
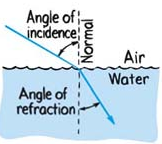
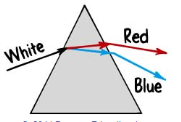
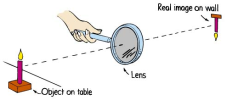
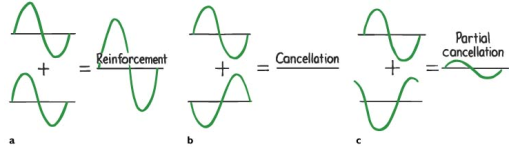
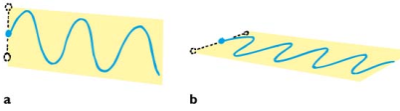
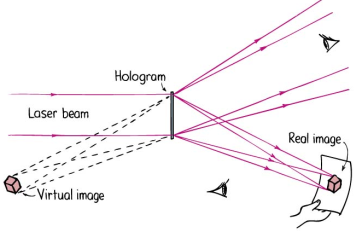


Light part 6 Notes

**Ch. 26: Properties of Light; 27: Color; 28 Reflection & Refraction; 29 Light Waves: 30 Light Emission**

1. Electromagnetic fields- An electric field surround a changing magnetic field. A magnetic field surrounds an electric current. If a magnetic field is oscillating it produces an oscillating electric field (& backwards). The vibrating electric and magnetic fields regenerate each other to make up an [**electromagnetic wave**](javascript:;), which emanates (moves outward) from the vibrating charge. *The electric and magnetic fields of an electromagnetic wave are perpendicular to each other and to the direction of motion of the wave.*
2. James Clerk Maxwell – “We can scarcely avoid the conclusion that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena. His work in electromagnetism has been called the second great unification in physics.” He calculated the speed of light and found it to be 300,000 km/sec and realized that EM radiation of any frequency propagates at the same speed as light. That light is EM radiation within a frequency of 4.3 × 1014 to 7 × 1014 vibrations/sec
3. **The Electromagnetic Spectrum-** classification of electromagnetic waves according to frequency- differing principally in frequency and wavelength; all travel at the same speed in free space. Because the vibrating electric and magnetic fields regenerate each other to make an electromagnetic wave, there is only one speed that allows the waves to remain in perfect balance. At only one speed does mutual induction continue indefinitely, carrying energy forward without loss or gain. If they speed up, energy would increase, if they are slower, the waves would cancel out. Law of conservation of energy. There is only one speed, it turns out, for which the electric and magnetic fields remain in perfect balance, reinforcing each other as they carry energy through space.
4. Since the speed of the wave is 300,000 kilometers per second, an electric charge oscillating once per second (1 hertz) will produce a wave with a wavelength of 300,000 kilometers.
5. Gravity can change the frequency of light or deflect light, but it can’t change the speed of light.
6. The universe is a dense sea of radiation in which occasional concentrates are suspended. EM waves surround us (ex. radio & TV signals) but you need a receiver that can pick up and vibrate with the same or close to the same vibrations (would be weaker signal if only close).
7. Materials- The natural frequency of the Material and the frequency of the light determine what is transmitted
8. **Transparent**- rays travel through in straight lines. - can see the image perfectly.
9. **Opaque**- absorbs light without reemitting it. Metals are shiny because light that shines on them forces free electrons into vibration and these vibrating electrons then emit their “own” light waves as reflection. Vibrations are turned into random kinetic energy, (become slightly warmer) —into internal energy.
10. **Translucent-** allows some light through but the light is scattered and does not have a clear image.
11. Relative wavelengths of red, green, and violet light. Violet light has nearly twice the frequency of red light, and half the wavelength.
12. Free electrons in every piece of metal on the Earth’s surface continually dance to the rhythms of waves.
13. The natural vibration frequencies of an electron depend on how strongly it is attached to its atom or molecule. Electrons in the atoms of glass have a natural vibration frequency in the ultraviolet range. when ultraviolet waves shine on glass, resonance occurs and the vibration of electrons builds up.
14. A wave of visible light incident upon a pane of glass sets up in atoms vibrations that produce a chain of absorptions and reemissions, which pass the light energy through the material and out the other side. Because of the time delay between absorptions and reemissions, the light travels through the glass more slowly than through empty space.
15. The energy any glass atom receives is either reemitted or passed on to neighboring atoms by collisions. , there is a slight time delay between absorption and reemission.
16. Resonating atoms in the glass can hold onto the energy of the ultraviolet light for quite a long time, and it collides with neighboring atoms and gives up its energy as heat. Glass is not transparent to ultraviolet light.
17. Glass is transparent to all the frequencies of visible light.
18. **Different materials have different molecular structures and therefore absorb or reflect light from various spectral ranges differently.**
19. **Speed of light c.** The speed of light in a vacuum is a constant 300,000 kilometers per second. In water, light travels at 75% of its speed in a vacuum, or 0.75 c. In glass, light travels at about 0.67 c, depending on the type of glass. In a diamond, light travels at less than half its speed in a vacuum, only 0.41 c. When light emerges from these materials into the air, it travels at its original speed, c.
20. ****Infrared waves, with frequencies lower than those of visible light, vibrate not only the electrons, but entire atoms or molecules which increases the internal energy and temperature of the structure (often called heat waves). Glass blocks both infrared and ultraviolet, but it is transparent to visible light.
21. Earth’s atmosphere is transparent to small amounts of ultraviolet that does get through and is responsible for sunburns. (would be fried to a crisp if it all got through)
22. Things look darker when they are wet because light bounces around inside the transparent wet region before it reaches your eye. Each bounce absorbs light and the surface looks darker.
23. **Shadows-** A thin beam of light is often called a ray.
24. [**Shadow**](javascript:;)—a region where light rays cannot reach.
25. sharp shadow- produce by either a large, far-away light (sun) source or a small, nearby light source
26. [**umbra**](javascript:;)**-**A total shadow ; penumbra - a partial
27. [**Solar eclipse**](javascript:;). the shadow of the Moon falls on the Earth-
28. Lunar Eclipse- A full Moon is seen when the Earth is between the Sun and the Moon. When this alignment is perfect, the Moon is in Earth’s shadow, and a lunar eclipse is produced

**The Eye-**

1. **cornea,** which does about 70% of the necessary bending of the light before the light passes through the pupil
2. **lens-** provides the extra bending power needed to focus images
3. **Retina**—back of eye where. The retina is not uniform
4. **blind spot**- a spot in the retina where nerves carrying all the information exit along optic nerve
5. **Fovea** - spot in the center of our field of view - the region of most distinct vision.
6. ****Two basic kinds of Antennae on retina- pick up light. Rods- black/white vision- stimulated by low-frequency light, predominate toward the periphery of the retina. Cones-responsible for color vision and are very dense in the fovea. There are three types of cones which are activated by differing frequencies of light. On the periphery of your vision, you can see an object and its color only if it is moving. Stars that look white are actually brightly colored. A time exposure reveals reds and red-oranges for the “cooler” stars and blues and blue-violets for the “hotter” stars.
7. Because a certain amount of information is combined from several visual receptors and “digested” in the retina it provides evidence of what you like or dislike. If we see, smell, taste, or hear something repugnant to us, our pupils automatically contract.
8. **27 Color-** Newton showed that sunlight can break up white light into the rainbow colors- ROYGBIV; also found that when a second prism was used to the rainbow, the colors were recombined to produce white light. The colors of things depend on the colors of the light that illuminates them, or the frequency of the light. Low frequencies- red; high frequencies- violet & blues
9. Objects only reflect part of the energy/frequencies which hit them while some light is reemitted; some is absorbed and warms the substance or passed through. The color you see when light hits something is based on that color being present in the light which hits the object and being reflected off. You see the color that is being reflected. White light contains all colors, so when an object is in white light, the color red would indicate that red is the color reflected and all other colors are absorbed and the object would heat up slightly. If a red ball is hit with a red light, the ball appears red because the red is reflected, but there are no other colors to be absorbed and no energy is absorbed. If a green light hits a red ball, the green is absorbed, but there is no red light to be reflected back and the object appears black. If a Purple (red + blue) light is shown on the ball, the ball will absorb the blue light and reflect the red, and will appear a red color.
10. The intensity of light from the Sun varies with frequency, being most intense in the yellow-green part of the spectrum. It is interesting to note that our eyes have evolved to have maximum sensitivity in this range.
11. All the colors added together produce white. The absence of all color is black. Red, green, and blue light can form white light.
12. [**Additive primary colors**](javascript:;). -Where two of the three colors overlap, another color is produced; any two of these colors of light add to produce another color.
13. **Complementary Colors-** two of the three additive primary colors are combined: Red + Blue = Magenta; Red + Green = Yellow; Blue + Green = Cyan.
14. We say that magenta is the opposite of green; cyan is the opposite of red; and yellow is the opposite of blue. When we add each of these colors to its opposite, we get white.
15. Magenta + Green = White (= Red + Blue + Green); Yellow + Blue = White (= Red + Green + Blue)  
    Cyan + Red = White (= Blue + Green + Red)
16. [**Complementary colors**](javascript:;). -When two colors are added together to produce white
17. Mixing pigments in paints and dyes is entirely different from mixing lights. Pigments are tiny particles that absorb specific colors. Pigments that produce the color red absorb the complementary color cyan. In effect, cyan has been subtracted from white light.
18. [**subtractive primaries**](javascript:;)**-** colors magenta, cyan, and yellow. Yellow, cyan, and magenta dyes will produce nearly any color in the spectrum. Something painted blue absorbs yellow, and so reflects all the colors except yellow. Take yellow away from white and you’ve got blue.
19. **Why the Sky Is Blue-** the blue of the sky,is the result of selective scattering. The tinier the particle, the greater the amount of higher-frequency light it will reemit. The nitrogen and oxygen molecules that make up most of the atmosphere are like tiny bells that “ring” with high frequencies when energized by sunlight. The reemitted light is scattered. Violet is scattered the most by nitrogen and oxygen in the atmosphere, followed by blue, green, yellow, orange, and red, in that order. The blue of the sky varies based on several factors. The principal factor is the water-vapor content of the atmosphere. On clear, dry days, the sky is a deeper blue than on clear days with high humidity. Pollution and other particles larger than oxygen and nitrogen molecules have lower frequencies and it takes on a whitish appearance. After a heavy rainstorm when the particles have been washed away, the sky becomes a deeper blue. In clean air, the scattering of high-frequency light provides a blue sky. When the air is full of particles larger than molecules, lower-frequency light is also scattered, which adds to the blue to give a whitish sky.
20. **Why Sunsets Are Red-** a sunbeam must travel through more of the atmosphere at sunset than at noon. As a result, more blue is scattered from the beam at sunset than at noon. By the time a beam of initially white light reaches the ground, only light of the lower frequencies survives to produce a red sunset.
21. Why Clouds Are White- A cloud is composed of water droplets of various sizes. The tiniest droplets scatter blue light, slightly larger ones scatter green light, and still larger ones scatter red light. The result is a white cloud.
22. **Why Water Is Greenish Blue-** Water is cyan because it absorbs red light. The froth in the waves is white because, like clouds, it is composed of a variety of tiny water droplets that scatter light of all the visible frequencies.
23. **Reflection- Light interacts with atoms as sound interacts with tuning forks causing vibrations.**
24. [**Fermat’s principle of least time**](javascript:;). Fermat’s idea was this: Out of all possible paths that light might travel to get from one point to another; it travels the path that requires the shortest time. **Principle of Least Time ;** light will take the most efficient path and travel in a straight line if there is nothing to obstruct the passage of light between the 2 points A lifeguard at a beach spots a person in distress in the water. You can run faster than you can swim. Should you travel in a straight line to get to B? The path of shortest time is shown by the dashed-line path, which clearly is not the path of the shortest distance. The amount of bending at the shoreline depends on how much faster you can run than swim. The situation is similar for a ray of light incident upon a body of water
25. **Law of Reflection-** different points on the mirror vary as to how long it takes the light to travel
26. [**law of reflection**](javascript:;), and it holds for all angles - **The angle of incidence equals the angle of reflection.**
27. It is customary to measure angles of incident and reflected rays from the reflecting surface- from a line perpendicular to plane of reflecting surface. This imaginary line is called the normal. The incident ray, the normal, and the reflected ray all lie in the same plane.
28. **Diffuse Reflection-** light is incident on a rough surface and is reflected in many directions. If the surface is so smooth there is very little diffuse reflection, and the surface is said to be polished. A surface may be polished for radiation of a long wavelength but not polished for light of a short wavelength.
29. **Refraction- process where** light bends in passing from one medium to another. A ray of light bends and takes a longer path when it encounters glass or water at an oblique angle but the longer path taken is nonetheless the path requiring the least time.
30. Refraction through glass. Example- **the prism** has opposite faces of the glass that are not parallel. Light that goes through will not follow a straight-line path b/c light will follow the solid line—and pass through a thinner section of the glass the prism. The path followed is the path of least time.
31. A converging lens- The curve decreases thickness of the glass correctly to compensate for the extra distances light travels to points higher on the surface.
32. **Mirage-** Viewing an object over hot pavement, we see a wavy, shimmering effect due to the various least-time paths of light as it passes through varying temperatures and therefore varying densities of air. The twinkling of stars results from similar phenomena in the sky
33. Light from the sky picks up speed in the air near the ground because that air is warmer and less dense than the air above. When the light grazes the surface and bends upward, the observer sees a mirage.
34. Because of refraction, submerged objects appear to be magnified.
35. Dispersion by a prism makes the components of white light visible
36. The speed of light in a transparent medium depends on its frequency.
37. Light waves with colors between red and violet travel at their own intermediate speeds.
38. Because different frequencies of light travel at different speeds in transparent materials, they refract by different amounts.
39. Plane Mirrors- **A virtual image is formed behind the mirror and is located at the position where the extended reflected rays (dashed lines) converge.** An observer sees an image of flame at this point but the rays do not actually come from this point, so the image is called a **virtual image**. The image is as far behind the mirror as he is in front and is the same size. It has the same color of clothing—evidence that light doesn’t change frequency upon reflection. The virtual image formed by a convex mirror (a mirror that curves outward) is smaller and closer to the mirror than the object. If object is close to a concave mirror (a mirror that curves inward like a “cave”), the virtual image is larger & farther away than the object. **Although each ray obeys the law of reflection, the many different surface angles that light rays encounter in striking a rough surface cause reflection in many directions.**
40. **Rainbows are** illustrations of dispersion. This separation of light into colors arranged according to frequency is called dispersion. All rainbows would be completely rounded if the ground were not in the way. A ray of sunlight enters a drop near its top surface some of the light is reflected & the remainder is refracted into water. **Sunlight incident on two sample raindrops, emerges from them as dispersed light. The observer sees the red light from the upper drop and the violet light from the lower drop. Millions of drops produce the whole spectrum of visible light.** Your cone of vision that intersects the cloud of drops that creates your rainbow is different from that of a person next to you. Everybody sees his or her own personal rainbow.
41. **Total Internal Reflection** - **Light emitted in the water is partly refracted and partly reflected at the surface.** The light striking the air–water surface obeys the law of reflection: The angle of incidence is equal to the angle of reflection. The only light emerging from the surface of the water is that which is diffusely reflected from the bottom of the bathtub. The critical angle for a diamond is about 24.5°, smaller than for any other known substance.
42. **Fiber Optics light** is “piped” by a succession of total internal reflections until it emerges at the top ends.
43. **Lensees**
44. [**Diverging lens**](javascript:;)**-** middle is thinner than the edges, and it diverges the light. The greatest deviation of rays occurs at the outermost prisms, for they have the greatest angle between the two refracting surfaces.
45. A converging lens provides an enlarged, right-side-up image only when the object is inside the focal point. **The image appears larger and farther from the lens than the object.**
46. a [**real image**](javascript:;) **When an object is far from a converging lens (beyond its focal point), a real upside-down image is formed.**
47.  When a diverging lens is used alone, the image is always virtual, right-side up, and smaller than the object.
48. **Lens Defects** - No lens provides a perfect image. A distortion in an image is called an [**aberration**](javascript:;).
49. Aberrations can be minimized using compound lenses, each consisting of several simple lenses, instead of single lenses.
50. Spherical aberration results from light that passes through the edges of a lens focusing at a slightly different place from where light passing near the center of the lens focuses
51. Chromatic aberration is the result of light of different colors having different speeds and hence different refractions in the lens b/c different colors of light do not come to focus in the same place.
52. Vision is sharpest when the pupil is smallest because light then passes through only the central part of the eye’s lens, where spherical and chromatic aberrations are minimal. You see better in bright light because in such light your pupils are smaller.
53. Astigmatism of the eye is a defect that results when the cornea is curved more in one direction than the other
54. Ch. 29
55. **Diffraction**- the bending of light; distortions. **C**onstructive and destructive interference is not restricted to easily seen water waves but is a property of all waves. Adding, or superposition, - in phase with each other produces a wave of the same frequency but twice the amplitude. If the waves are exactly one-half wavelength out of phase, their superposition results in complete cancellation and **partial cancellation** occurs.
56. **B**oth longitudinal and transverse waves exhibit interference and diffraction effects.
57. **Polarization-** the waves traveling along the rope are confined to a single plane  
    Sound waves are longitudinal, which means the vibratory motion is along the direction of wave travel. Light waves are transverse. A common light source—such as an incandescent lamp, a fluorescent lamp, a candle flame, or an arc lamp—emits light that is unpolarized. If you look at unpolarized light through a Polaroid filter, you can rotate the filter in any direction, and the light will appear unchanged. But if you are looking at polarized light and you rotate the filter, you can progressively cut off more and more of the light until it is entirely blocked out
58. **Holography-** the light must be of a single frequency and all parts exactly in phase: It must be **coherent.** Only a laser can easily produce such light. Holograpraphy has a two dimensional photographic plate illuminated with laser light that allows you to see a faithful reproduction of a scene in 3D. It is so realistic you can actually look around the sides. No lens is used.

**Ch. 30 Light emission**

1. **Fluorescence-** In fluorescence, the energy of the absorbed ultraviolet photon boosts the electron in an atom to a higher energy state. When the electron then returns to an intermediate state, the photon emitted is less energetic and therefore of a lower frequency than the ultraviolet photon.
2. **Fluorescent Lamps-** A fluorescent tube. Ultraviolet (UV) light is emitted by gas in the tube excited by an alternating electric current. The UV light, in turn, excites phosphors on the inner surface of the glass tube, which emit white light
3. Phosphorescence- When excited, certain crystals as well as some large organic molecules remain in a state of excitation for a prolonged period of time and become “stuck.” As a result, there is a time delay between the processes of excitation and de-excitation. Used to make glow in the dark objects. A TV screen is slightly phosphorescent, with an afterglow which may last more than an hour. Many living creatures—from bacteria to fireflies and larger animals, such as jellyfish—chemically excite molecules in their bodies that give off light. We say that such living things are bioluminescent. Under some conditions, certain fish become luminescent when they swim but remain dark when still. Schools of these fish hang motionless and are not seen, but, when they are alarmed, they streak the depths with sudden light, creating a sort of deep-sea fireworks. The mechanism of bioluminescence is not well understood and is currently being researched.
4. **Lasers-** (light amplification by stimulated emission of radiation). Was predicted by Albert Einstein in 1917. A beam of incoherent light spreads out after a short distance, becoming wider and less intense with increased distance.   
       A beam of photons having the same frequency, phase, and direction—that is, a beam of photons that are identical copies of one another—is said to be **coherent**. A beam of coherent light spreads and weakens very little.   
       A laser is a device that produces a beam of coherent light. Every laser has a source of atoms called an active medium, which can be a gas, liquid, or solid (the first laser was a ruby crystal). The atoms in the medium are excited to metastable states by an external source of energy. When most of the atoms in the medium are excited, a single photon from an atom that undergoes de-excitation can start a chain reaction. This photon strikes another atom, stimulating it into emission, and so on, and producing coherent light. Most of this light is initially moving in random directions. Light traveling along the laser axis, however, is reflected from mirrors coated to reflect light of the desired wavelength selectively. One mirror is totally reflecting, while the other is partially reflecting. The reflected waves reinforce each other after each round-trip reflection between the mirrors, thereby setting up a to-and-fro resonance condition wherein the light builds up to an appreciable intensity. The light that escapes through the more transparent-mirrored end makes up the laser beam.
5. **A laser beam is not seen unless it scatters off something in the air. Like sunbeams or moonbeams, what you see are the particles in the scattering medium, not the beam itself. When the beam hits a diffuse surface, part of it is scattered toward your eye as a dot.**  Lasers have found wide use in surgery. Communications can be carried in a laser beam directed through space, through the atmosphere, or through optical fibers (light pipes) that can be bent like cables. The laser is at work at supermarket checkout counters.     Surveyors use reflected laser light to measure distance. Home hobbyists and carpenters use them for levels. Environmental scientists use lasers to measure and detect pollutants in exhaust gases

Mirages- light moves faster in hot air (curves toward cooler) Image is transferred

When light slows going through different medium- it may refract toward normal (causes submerged objects to appear nearer

Dispersion- separation or separating of light

Rainbows

* Full circle if in an airplane (standing on the ground- the bottom is cut off- producing arch)
* Water drops act as prisms
* Edge of 3D cone
* Moves as you move- your neighbor does not see exactly the same thing
* 2nd rainbow- is a double refraction (bends 2 X in raindrop)
  + Dimmer and colors are reversed

Total internal reflection

* -light is totally reflected in medium
* Critical angle for water – 48 degrees
* Only light emitted is diffusely reflected
* Diamonds critical angle- 24.5 degrees. b/c light slows as enters, the light is great and seems brighter
* Fiber Optics- total internal reflection- used for communication, medicine, (messages w/lasers)
* Pg 572 Polarized light- light moves only in one direction- 2 lens turned at 90 degrees- no light goes through
* Pg 576 Hologram- wave fronts interfere to produce image
* Pg 585 Emission Spectra- patterns indicate elements
* Pg. 586 Incandescent- something glows b/c of high temp (sun)
* Reflection- earth shine, moon shine
* Pg 589- Fluorescent- UV excites atoms/electrons (light is re-emitted when de-exciteed
* Pg 605 light- wave particle duality ( as waves when bounces back, as particles as it interacts w/matter)
* Pg 610- Uncertainty Principle- measuring something may affect the object being measured.

